REMARKS

Claims 1–20 are pending in the present application.

Claims 1–7 have been withdrawn.

Claims 1–9, 11–12, 14 and 16–19 were amended herein.

Reconsideration of the claims is respectfully requested.

35 U.S.C. § 102 (Anticipation)

Claims 8 and 10–14 were rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,060,787 to *Zhao et al.* Claims 8–12, 14 and 16–19 were rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,054,383 to *Suzuki et al.* These rejections are respectfully traversed.

A claim is anticipated only if each and every element is found, either expressly or inherently described, in a single prior art reference. The identical invention must be shown in as complete detail as is contained in the claim. MPEP § 2131 at p. 2100-76 (8th ed. rev. 3 August 2005).

With respect to the rejection over *Zhao et al*, independent claims 8 and 16 each recite an etch protective barrier layer comprising a material for which removal by chemical mechanical polishing is primarily mechanical. Such a feature is not found in the cited reference. The third protective layer 307 in *Zhao et al* that is cited in the Office Action as satisfying this limitation is a CVD tungsten layer. *Zhao et al* does NOT teach or suggest that removal of tungsten by CMP is primary

mechanical. The specification of the present application, however, teaches that removal of tungsten by CMP is primarily chemical:

> Chemical mechanical polishing of tungsten, however, is highly chemical in nature. Tungsten removal by known chemical mechanical polishing processes is quite uniform across the surface of the layer, and is nearly independent of topography.

Specification, page 14–18. Thus, there is no basis in the record for concluding that tungsten is a material for which removal by CMP is primarily mechanical as recited in the claims.

The Office Action states:

> The barrier layer comprises a material for which removal by chemical mechanical polishing is primarily mechanical because the tungsten barrier layer (307) resists attack by the polishing slurry (col. 6, lines 3–19).
>
> . . . .
>
> Zhao state that the tungsten barrier is more resistant to slurry attack, which means that the layer is resistive to the chemicals in the CMP slurry. Therefore, it [sic] the tungsten protective layer resists the chemicals in the CMP slurry, then the polishing step relies mostly on the mechanical part of it.

Paper No. 20060226, page 2. However, nothing in *Zhao et al* supports the conclusion that removal of tungsten protective layer 307 is primarily mechanical. First, *Zhao et al* states that nucleation layer tungsten 307 is more resistant to slurry attack, a relative statement intended to convey that nucleation layer tungsten 307 is more resistant to slurry attack than bulk tungsten:

> As with conventional tungsten layers, CVD deposition is substantially conformal. Therefore, a deposition trench 312, which follows the contours of the original alignment mark trench 300, remains in the surface of the wafer 310 following tungsten deposition. However, whereas conventionally the walls of the deposition trench are formed from bulk tungsten, in this embodiment of the present invention the walls 314 are formed from the protective third tungsten layer 307 which covers

> the bulk layer 306. As in the conventional case, the deposition trench 312 ultimately serves as an alignment mark. However, the fine grain size and equiaxed grain structure of this nucleation layer 307 make it more resistant and more uniform in response to slurry attack than the underlying bulk tungsten layer 306. As a result, the deposition trench 312 remains a consistent and reliable alignment mark.

Zhao et al, column 6, lines 3–19. *Zhao et al* is concerned with preserving alignment marks during CMP polishing:

> The present invention provides a method and composition for obtaining consistent alignment mark profiles with both detectibility and detection accuracy for use in conjunction with CMP planarization processes in semiconductor fabrication. The method and composition reduce the rate of and increase the uniformity of oxidation of alignment mark trench side walls by CMP slurry accumulating in an alignment mark trench during CMP processing. In a preferred embodiment, a thin protective layer of tungsten having an equiaxed grain structure with fine grain size and conformity is deposited over a conventionally applied bulk tungsten layer prior to commencing CMP operations. As a result, the tungsten trench profile remains a consistent and reliable alignment through CMP processing.

Zhao et al, column 4, lines 54–67. The cited portion of *Zhao et al* thus contains no teaching that removal of tungsten layer 307 by CMP is primarily mechanical. *Zhao et al* merely teaches that when layer 307 is formed by nucleation, the fine grain size and equiaxed grain structure makes the tungsten more resistant to slurry attack – more resistant that bulk tungsten.

Second, there is no basis for concluding, as asserting in the Office Action, that "more resistant to slurry attack" means that removal by CMP is primarily mechanical. Even if the nucleation layer tungsten is more resistant to the chemicals in a CMP slurry than bulk tungsten, it does not necessarily follow that removal by CMP is therefore primarily mechanical rather than primarily chemical. Simply because removal by CMP may be less chemical for nucleation layer

tungsten than for bulk tungsten DOES NOT indicate that removal of nucleation layer tungsten by CMP is primarily mechanical while removal of bulk tungsten is primarily chemical. The difference is merely one of degree (comparatively more or less chemical), not necessarily of character (primarily mechanical or primarily chemical). Accordingly, the inference drawn in the Office Action that removal of nucleation layer tungsten 307 by CMP is primarily mechanical lacks positive support within the record, and is therefore arbitrary and capricious.

Finally, the inference drawn in the Office Action is directly contrary to the teachings in the specification that removal of tungsten by CMP is primarily chemical. Therefore the inference is arbitrary and capricious.

As previously noted, the cited portion of U.S. Patent No. 6,436,814 to *Horak et al* teaches that the "barrier function" of conductor liner 510 is against oxidation, NOT against chemical etching and/or removal by abrasion:

> Additionally and shown in FIGS. 5 and 9, conductor 501 could include conformal conductor liner 510 and conformal conductor 520. Conformal conductor liner 510 would be the protective barrier lining the sidewalls of opening 340 and recess 330, and would be between conformal conductor 520 and insulator 310. For example, if conformal conductor 520 was CVD tungsten, conformal conductor liner 510 would prohibit the very aggressive oxidizing chemistry of CVD tungsten from affecting insulator 310 or any other underlying materials. Additionally, because conformal conductor liner 510 and conformal conductor 520 are preferably conformal conductive materials, they are easily capable of filling high aspect ratio structures, recursive structures, and the like. Thus, materials capable of being conformal conductor liner 510 and conformal conductor 520 include tantalum nitride/tantalum, tantalum/tantalum nitride, tantalum/copper, tantalum nitride/copper, tungsten nitride/tungsten, tungsten/tungsten nitride, titanium nitride/titanium, and titanium/titanium nitride.

Horak et al, column 5, lines 34–52. Nothing in *Horak et al* supports the inference that removal of tungsten by CMP – whether bulk tungsten or nucleation layer tungsten – is primarily mechanical.

With respect to the rejections over *Zhao et al* and *Suzuki*, independent claims 8 and 16 each recite that the tungsten layer underlying the protective barrier layer fills the opening within the dielectric layer. Such a feature is not found in the cited references. *Zhao et al* depicts the upper surface of conformal layer 306 and being below the upper surface of dielectric layer 302 through which the opening is formed:

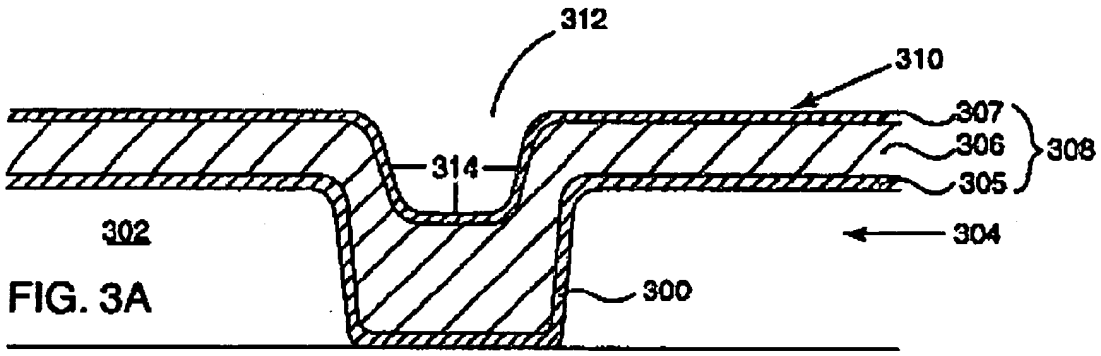


FIG. 3A

Zhao et al, Figure 3A. The relative positions of the upper surfaces of conformal layer 306 and the upper surface of the dielectric layer 302 in *Zhao et al* is even more apparent from Figure 3B, which depicts the structure after chemical mechanical polishing:

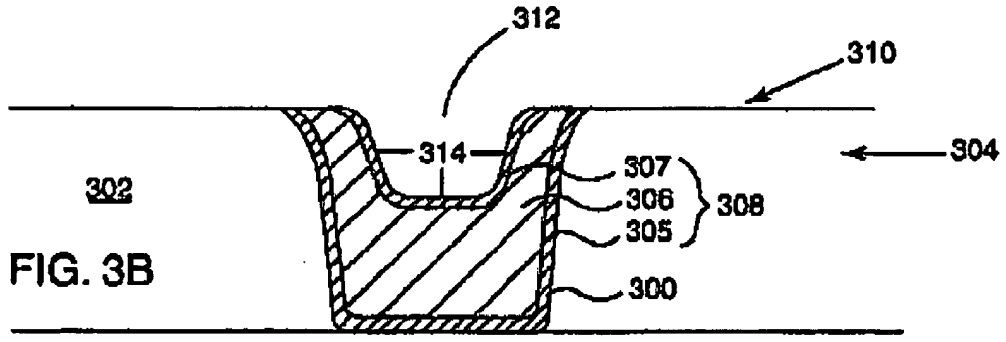
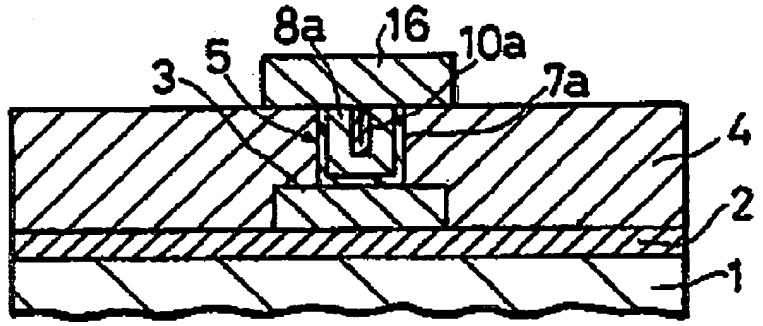


FIG. 3B

Zhao et al, Figure 3B. Similarly, tungsten 8a in Figure 2D of *Suzuki et al* does not fill the opening in insulator 4:

FIG. 2D



Suzuki et al, Figure 2D.

With respect to the claim limitation of the tungsten layer filling the opening within the dielectric layer, the Office Action states:

> In re the arguments that Zhao and Suzuki do not show that the tungsten conformal layer fills the opening of the dielectric layer, the examiner believes that the

> references also teach this element of the claims. If Zhao and Suzuki do not show this element, then the applicant's own invention also does not show that the tungsten conformal layer fills the opening. If the barrier layer (202) is within the opening of the dielectric as shown in the applicant's figure 2B, then the tungsten of the instant invention also does not fill the opening and the claims are not supported by the specification and drawings. However, since the claims discloses that the protective barrier layer is over the tungsten and within the openings, then the tungsten layer does not fill the openings completely and to the top surface of the dielectric. Thus, Zhao and Suzuki show the limitations in question because the barrier layers are formed over tungsten layer and within the opening. In both references, the tungsten layer is formed to the top surface of dielectric layer and primarily fills the opening.

Paper No. 20060226, page 8. However, Applicants' specification DIFFERENTIATES the embodiment of FIGURES 2A and 2B (cited in the above quote) from the embodiments of FIGURES 1A through 1C on the basis that THAT embodiment does not disclose the tungsten layer 200 filling the openings 102–104 through the dielectric layer 100:

> FIGURES 2A-2B depict cross-sections of an integrated circuit structure during various stages of a process for selectively forming tungsten metal regions by chemical mechanical polishing according to another embodiment of the present invention. The basic structure and process is identical to that depicted in FIGURES 1A through 1C and described above. In this embodiment, however, the tungsten layer 200 is formed with a thickness which is insufficient to fill the openings 102-104 (i.e., less than the thickness of dielectric layer 100), although the overlying protective barrier layer 108 fills any remainder of openings 102-104 not filled by tungsten layer 200.

Specification, page 14, lines 3–14. FIGURE 1C of the drawings depicts tungsten layer regions 111 filling those portions of openings 102, 103 and 104 that are not filled by multilayer conformal barrier and/or adhesion layer 105/106:

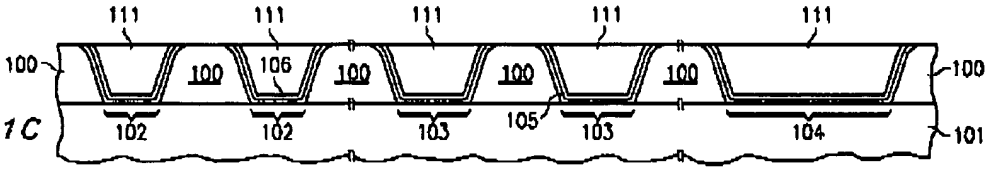


FIG. 1C

The Office Action attempts to interpret "fill" (or equivalently "filling") both as being satisfied by tungsten partially filling the opening, leaving a portion unfilled in the upper region of the opening, and as requiring that tungsten completely fill the openings with no other material being present in any other part of the openings. Such interpretation is both logically inconsistent, internally, and inconsistent with use of the term within the specification and claims. As used in this application, "fill" and "filling" refer to filling an unfilled, upper portion of the openings through dielectric.

Amended independent claim 16 recites that an upper surface of the tungsten has an arcuate shape across substantially all of the width of the opening. Such a feature not found in *Suzuki et al.* *Suzuki et al* teaches that tungsten layer 8 has a thickness of between 1/5 and 2/5 (preferably 1/3) of the diameter of via hole 5. Accordingly, after CMP, the tungsten within the via hole 5 has a upper surface that is substantially planar for between 2/3 and 4/5 of the width of the via hole 5. The upper surface of the tungsten in *Suzuki et al* is therefore not arcuate for substantially all of a width of the opening.

Therefore, the rejection of claims 8–14 and 16–19 under 35 U.S.C. § 102 has been overcome.

35 U.S.C. § 103 (Obviousness)

Claim 9 was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Zhao et al* in view of *Horak et al*. Claim 15 was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Zhao et al* in view of U.S. Patent No. 6,346,741 to *Van Buskirk et al*. Claims 13, 15 and 20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Suzuki et al* in view of *Van Buskirk et al*. These rejections are respectfully traversed.

As noted above, independent claim 8, from which rejected claims 9, 13 and 15 depend, recites that the conformal tungsten layer underlying the protective barrier layer fills the opening within the dielectric layer. Such a feature is not found in the cited references. As previously noted, such a feature is not shown or described in *Zhao et el* or *Suzuki et al*. Similarly, neither *Horak et al* nor *Van Buskirk et al* depict a conformal tungsten layer filling an opening through a dielectric layer.

Independent claim 8, from which claims 9 and 15 depend, also recites that the protective barrier layer over the tungsten within the opening through the dielectric comprises a material for which removal by chemical mechanical polishing is primarily mechanical. As previously noted, *Zhao et al* does not disclose such a feature. No motivation or incentive for substituting materials disclosed in *Horak et al* and/or *Van Buskirk et al* for the nucleation layer tungsten 307 in *Zhao et al* has been identified.

Independent claim 16, from which claim 20 depends, recites that the upper surface of the tungsten has an arcuate shape across substantially all of a width of the opening. Such a feature is not found in *Suzuki et al*, *Horak et al* and/or *Van Buskirk et al*.

Therefore, the rejection of claims 9, 13, 15 and 20 under 35 U.S.C. § 103 has been overcome.

If any issues arise, or if the Examiner has any suggestions for expediting allowance of this Application, the Applicant respectfully invites the Examiner to contact the undersigned at the telephone number indicated below or at ***dvenglarik@munckbutrus.com***.

The Commissioner is hereby authorized to charge any additional fees connected with this communication or credit any overpayment to Deposit Account No. 50-0208.

Respectfully submitted,

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